THERMOPLASTIC MOLDING PROCESS

RELATED APPLICATIONS

The instant application claims priority from United States Provisional Patent Application Serial No. 60/409,217, filed September 9, 2002.

FIELD OF THE INVENTION

The invention provides a novel thermoplastic molding process useful in the manufacture of hollow, deformable thermoplastic articles such as hollow doll heads. In the process of the instant invention, a parison is formed at a first injection station and is transferred to a blow mold station. At the blow mold station, the parison is transformed into a hollow, deformable thermoplastic article through application of a vacuum and gas injection. Articles made by the process of the instant invention have a highly realistic appearance and texture.

BACKGROUND OF THE INVENTION

Traditionally, soft, hollow toy parts such as doll heads were made by either by slush molding, dip molding, or rotocasting processes using latex or PVC, or by blow-molding processes using thermoplastic elastomers. These traditional processes, however, are not able to make hollow parts with controllable and precise wall thicknesses and opening dimensions. Nonetheless, due to the softness and easy processing of PVC, slush molding and rotocasting processes using PVC have been the primary process and the primary material for making one-piece hollow doll heads with direct hair rooting in the past half century.

In the last decade, questions regarding the environmental safety of PVC have lead some toy manufacturers to elect to discontinue PVC use in toys and dolls. Use of materials other than PVC has created the need for new processes for making soft hollow toy parts with controllable and precise wall thickness and opening dimensions.

In United States Patent No. 6,403,003 ("'003 Patent"), the complete disclosure of which is incorporated herein by reference, a method is provided for making a soft hollow part for a toy, such as a head for a doll. The method includes providing an injection moldable flexible thermoplastic elastomer, and providing a mold for the head part. The mold includes exterior mold parts and an interior core part, wherein the exterior mold parts are spaced apart from the interior core to define a cavity in the shape of the hollow part to be formed. The thermoplastic elastomer is injected into the mold cavity to form the hollow head. The head has an opening for removing the interior core, but the dimension of the core is larger than the dimension of the opening through which the core must be removed. After the head is injection molded, the exterior mold parts are opened to release the head and interior core, and then the interior core is removed from the head by extracting it through the opening in the head.

Preferably, the method disclosed and claimed in the '003 Patent uses a non-PVC thermoplastic elastomer. In particular, a family of flexible thermoplastic elastomers known as S-B-S (Styrene-Butadiene-Styrene), S-I-S (Styrene-Isoprene-Styrene) and S-EB-S (Styrene-Ethylene/Butylene-Styrene), marketed by Shell Chemical Company under the name KRATON, is preferred because of its resilience, strength and durability, as well as the ability to be painted and passing the general paint adhesion requirements for toys and dolls applications. An S-B-S copolymer, such as the copolymer marketed as KRATON D, is a particularly preferred elastomer. This copolymer is reported to be environmentally friendly and safe.

In a second aspect of the invention of the '003 Patent, a mold is provided for making an injection molded hollow article, such as a doll head, using a thermoplastic elastomer. The mold includes an exterior mold portion and an interior core assembly. The exterior mold portion includes at least two separable sections for enclosing the interior core assembly. The interior core assembly fits inside the exterior mold portion. The interior core is spaced apart from the exterior mold portion to define a variable-thickness cavity having the shape of the hollow article to be molded and into which a melted thermoplastic elastomer may be injected to form the hollow article. The hollow article takes the shape of the cavity and includes an opening through which the interior core is

removable. The interior core assembly has a cross-sectional dimension that is larger than the dimension of the opening in the hollow article from which it must be removed after the article is molded. Accordingly, this mold is useful for making a variety of hollow toy parts that have a narrow opening, such as heads, feet, or hands.

The '003 Patent provides a method of making a doll head without an observable part line. When the head is injection molded, a part line is created at the junction of two exterior mold halves. The part line extends in a continuous line around the top of the head above the ears. Hair-material is rooted to the top of the doll head above and below the part line with a sufficient density such that the part line is not observable to an ordinary observer holding the doll at arms length.

Preferably, the invention of the '003 Patent takes advantage of certain mold structures to make the soft hollow parts and dolls heads. A two-part solid core design with a mushroom-shaped ejector pin, double-ejection system may be used to locate the parting line at the top part of head within the hair rooting area, as shown in Figures 6-8 of the '003 Patent, to make the part line not observable to the ordinary observer.

While the process of the '003 Patent enables the manufacture of soft hollow toy parts and doll heads and provides for controllable and precise wall thickness at specific locations, the exact wall thickness formed is sometimes greater than desired. Because the thermoplastic elastomer is not forcibly dispersed against the top and bottom mold halves before it sets to form the doll head, the head forms with a thickness equivalent to the entire volume of the cavity. Due to tool structure limitations, the process of the '003 Patent produces, in some cases, doll heads with sections that are thicker than otherwise desired. For example, the doll chin might be too thick. This in turn limits the deformability of the doll head, hence hindering its application in squeeze toys and dolls in which appendage deformation accentuates a realistic appearance. Additionally, formation of undesirably thick sections requires application of a higher holding pressure and a longer holding time to in order to cool and solidify the article without the development of shrinkage marks.

The need exists, therefore, for a thermoplastic molding process useful in the manufacture of hollow, deformable articles such as doll heads which have a relatively uniform and minimum thickness and which are free of manufacturing flaws such as shrinkage marks. Ideally, such a process would facilitate the removal of a manufactured article from a mold without damage to any features of the article.

OBJECTS OF THE INVENTION

It is an object of the instant invention to provide a thermoplastic molding process for the manufacture of hollow, deformable articles such as doll heads.

It is a further object of the instant invention to provide a thermoplastic molding process for the manufacture of hollow, deformable articles such as doll heads that have a relatively uniform and minimum thickness and that are free of manufacturing flaws such as shrinkage marks.

It is a still further object of the instant invention to provide a thermoplastic molding process for the manufacture of hollow, deformable articles such as doll heads which facilitates the removal of a manufactured article from the mold without damage to any features of the article.

SUMMARY OF THE INVENTION

In accordance with the above-stated objects, the instant invention provides an improved method of making hollow, deformable hollow thermoplastic articles. In the method of the instant invention, a thermoplastic elastomer is first injected at an injection station into a first mold comprising a two-part solid core design. The first mold comprises exterior mold parts, an interior core, and an injector pin. The exterior mold parts are spaced apart from the interior core to define a cavity in the shape of a substantial portion of the finished article. For example, the first mold may define that portion of a hollow doll head which extends below the hairline. Significantly, in a novel feature of the present invention, pressure is not maintained at the injection station until the injected elastomer (parison) is solidified. Instead, prior to parison solidification, the parison is

transferred to a blow station comprising a second mold where, under vacuum and gas injection, the parison is relatively uniformly dispersed at a minimal thickness against the interior of the second mold cavity, and is thereafter cooled and solidified.

A vacuum is drawn through a valve pin inserted through the blow station mold cavity while pressurized gas is simultaneously injected into the parison through a movable core pin. This synergistic application of vacuum and gas injection disperses the parison material relatively evenly against the unfilled blow station mold cavity surface at a minimum thickness to form deformable, hollow thermoplastic articles, such as a hollow doll head. The temperatures and pressures maintained at the blow station ensure that the parison sets to form a deformable, hollow thermoplastic article that is substantially free of undesirable stress or burn marks.

Upon formation of the hollow, deformable thermoplastic article, the blow station mold front half is separated from the blow station mold rear half and the mold rear half is opened for ejection of the deformable hollow thermoplastic article. An ejector pin then moves forward and pushes the article out from the blow station mold cavity. In the case of a doll head, undercut features such as the nose, ears, mouth, and teeth are able to deform, collapse and release from the mold cavity without tearing or other damage. Further, the minimum head thickness facilitates compressed gas ejection of the head from the ejector pin.

A hollow, deformable thermoplastic article made by the process of the instant invention (i) has a thickness that is substantially less than the volume of the blow station mold cavity, and (ii) is more deformable than an article made by the process of the '003 Patent. The method of the instant invention is therefore particularly useful in making squeeze toys for younger children and in making dolls in which appendage deformation accentuates a realistic appearance.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1A illustrates cross sectional views of the injection mold station comprising a mold with a two-part solid core design having front and rear halves with a mushroom-

shaped ejector pin, and FIGURE 1B illustrates cross sectional views of the parison injection at the injection mold station.

FIGURE 2 illustrates a cross-sectional view of the transfer of the parison to the blow mold station.

FIGURE 3 illustrates parison dispersion at the blow mold station.

FIGURE 4 illustrates a dispersed parison subsequent to removal of the blow station mold front half.

FIGURE 5 illustrates mechanical ejection of a doll head from the blow station mold cavity through use of an ejector pin.

FIGURE 6 illustrates compressed gas ejection of a doll head from the blow mold station.

DETAILED DESCRIPTION OF THE INVENTION

As used herein, the following terms have the following respective meanings.

The terms "front", "rear", "left", "right", "top", "bottom", "height", or "width" are provided from the viewpoint of the normal upright position of a deformable hollow thermoplastic article, e.g., a doll head, when taken from the perspective of the article and are used herein as an aid to identify and describe the different features of the preferred embodiments of the invention. Those directional terms are not meant, however, to limit the invention in any respect.

The term "injection moldable flexible thermoplastic elastomer" includes polyvinyl chloride (PVC), ethylene vinyl acetate copolymer (EVA), any of the polymers sold under the trademark KRATON by Shell Chemical Co. (such as optionally hydrogenated) styrene-ethylene/butylene-styrene (S-EB-S), styrene-butadiene-styrene (S-B-S), styrene-isopropene-styrene (S-I-S), styrene-diene, styrene-isoprene and styrene-butadiene block copolymers, styrene-ethylene-butylene block copolymer containing mineral oil, branched styrene copolymer, styrene-butadiene rubber, styrene-butadiene triblock rubber, styrene-isoprene-styrene linear block polymer, styrene-butadiene radial block copolymer, butadiene-styrene copolymer rubber, or synthetic rubber) and low

density polyethylene (LDP). Another potentially suitable thermoplastic elastomer is sold by Monsanto under the name SANTOPRENE. Preferably, an S-B-S, S-I-S or S-EB-S copolymer is used. A S-B-S copolymer is preferred.

Preferably, the thermoplastic elastomer is sufficiently flexible to stretch and allow the larger interior core pieces to be extracted from the interior of the hollow molded parts. A thermoplastic elastomer useful in molding realistic, deformable, hollow thermoplastic articles such as soft hollow toy parts is preferred. The elastomer should not pose any difficulty in molding detail, removal of the molded parts from the mold, or removal of larger cores through smaller openings.

In particular, a thermoplastic elastomer marketed by Shell Chemical Company under the name KRATON D is preferred because of its resilience, strength and durability, and its ability to form a strong and reliable solvent bond (e.g., using Toluene as the solvent). KRATON D is an S-B-S block copolymer, and is reportedly suitable for food and drug use applications, making it a good choice for use in toy parts where there is concern about the harmful effects of the toy material on children. KRATON D has a normal processing temperature range of 150° C to 200° C, and a typical injection pressure of between 500 psi and 1000 psi, as noted in the Shell Chemical Technical Bulletin, SC:455-96. The injection molding methods of this invention work within the normal established processing parameters for KRATON D, and require no special processing requirements. It is also expected that other materials would not require special processing parameters to be used.

In regard to the flexibility and stretchability of the material used to make the hollow toy parts, KRATON has an elasticity, or elongation, that ranges up to between about two hundred fifty and five hundred fifty percent, depending on the grade selected. If a grade of elastomer is used in this invention with a higher elongation, then a larger interior core piece may be removed through a smaller opening in the toy part. The amount of force required to extract the undercut core will depend on the wall thickness of the toy part around the opening, and how much that opening needs to be stretched. The opening should not be stretched too far to prevent tearing or damage to the toy part.

The invention is described hereinafter with respect to the preferred embodiment of a doll head. However, such description is not meant to limit the term "hollow deformable thermoplastic article". "Hollow deformable thermoplastic article" includes elastomeric parts that may be made by injection molding and that are adaptable to mold-parison injection and dispersion steps such as those of the instant invention. The term can include mannequin appendages, elastomeric items used in diving or safety gear, and toy parts, including but not limited to parts of figurines resembling human characters. Further, as used herein, the term "doll head" could be the head of any toy, figurine, souvenir, animatronic robot, and the like, that represents a human figure, an animal, living or extinct, or even a fictitious character of unknown origin, such as an alien from another planet.

Figure 1A and Figure 1B illustrate a parison injection station used in the method of the instant invention comprising a double-ejector system for removal of a doll head from a mold. Referring to Figure 1B, parison 1 defining a portion of a doll head is shown inside exterior mold halves defining an injection station first mold comprising a top mold half 3 and a bottom mold half 5. As illustrated in Figure 1B, parison 1 defines that portion of a complete doll head below a latitudinal plane intersecting the head at a position above the eyes and below the crown of the head. As illustrated in Figures 1A and 1B, inside the first mold halves, there is an interior core assembly 7 through which extends ejector pin 13. Ejector pin 13 has a concentric hollow tube (not shown), which extends throughout its length for transmission of a compressed gas. The ejector pin 13 ends with a mushroom-shaped cap 15 in sleeve 11 of interior core assembly 7. As illustrated in Figure 1A, first mold cavity 17 between first mold exterior mold halves 3 and 5 and the core assembly 7 is in the shape of the aforementioned parison 1. In the method of the instant invention, thermoplastic elastomer is first injected inside first mold cavity 17 to form parison 1.

In the process of the instant invention, the injection molding processing conditions are influenced by the type and grade of thermoplastic elastomer selected. For example, in a typical injection molding process, the bulk of the materials of the composition are thoroughly mixed to provide a uniform feedstock. The feedstock is next

processed for injection into an injection mold. In another vessel, pigment, polystyrene and a small portion of the thermoplastic elastomer (such as S-B-S copolymer) are mixed to homogeneity.

The prepared feedstock and the pigment-bearing mixture are injected at the injection station into the first mold, generally over a period of from about 0.2 to about 6 seconds, typically from about 0.5 to about 4 seconds, and preferably from about 1 to 3 seconds. This period enables the thermoplastic elastomer to fill first mold cavity 17 properly without over-stressing and allows the compressed gas to vent properly, thereby avoiding parison burning. The injection station pressure is determined by the particular thermoplastic elastomers employed and generally varies from about 200 psi to about 1000 psi, typically from about 300 psi to about 800 psi, and preferably from about 400 psi to about 700 psi. The injection station temperature is generally from about 150° C to about 300°, typically from about 160° C to about 220° C and preferably from about 175° C to about 200° C.

Optionally, any gas present in the first mold prior to the beginning of the elastomer injection cycle may be removed from the first mold by means of a vacuum assist coordinated with the injection of the elastomer composition. A vacuum can be drawn for a few seconds prior to the end of the elastomer injection period. It is to be noted that applying the vacuum assist too early in the injection period may result in overly large cell spaces within the first mold, yielding an overly spongy parison. However, failure to use a vacuum assist may result in increased cycle times. Optimization of the vacuum assist step will be influenced by parameters including elastomer composition and temperature.

Next, parison 1 is transferred to a blow station comprising a second mold illustrated in Figure 2. Second mold front half 19 is substituted for parison injection station mold front half 3 illustrated in Figure 1B. As illustrated in Figure 2, cavity 21 of second mold front half 19 defines the remaining portion of the doll head not otherwise defined by first mold cavity 17 illustrated in Figure 1A.

Referring to Figure 3, high pressure compressed gas is next injected through the tube in ejector pin 13 and a vacuum is drawn in cavity 23 through suction pressure applied through pin 25. As a result of this gas injection and application of vacuum, parison 1 is dispersed relatively uniformly against the surfaces of second mold halves 5 and 19 defining cavity 23 to form a hollow, deformable doll head 27.

The second mold cavity vacuum pressure ranges from about -7 psig (gauge pressure) to about -14.5 psig, typically from about -9 psig to -14.3 psig, and preferably from about -11 psig to about -14.0 psig. The pressure of the compressed gas injected into the second mold ranges from about 80 psig to about 1000 psig, typically from about 120 psig to 600 psig and preferably from about 180 psig to about 400 psig. No special venting of this gas is required. The compressed gas temperature preferably ranges from about 30° C to 40° C to help to cool the blown parison without subjecting it to undue stress caused by temperature shock. The blown and expanded parison 1 is generally maintained and sets within the second mold from about 5 seconds to about 90 seconds, typically from about 10 seconds to about 80 seconds, and preferably from about 15 seconds to about 30 seconds. It is preferred that molding at the blow station occurs as quickly as possible.

After a time period sufficient for parison 1 to harden effectively within the blow mold station, the second mold is opened and deformable doll head 27 is removed as follows. Referring to Figure 4, subsequent to the dispersion of parison 1, second mold front half 19 (illustrated in Figure 3) is removed. Next, as illustrated in Figure 5, doll head 27 is partially ejected mechanically from bottom mold half 5 through upward movement of ejector pin 13. Some force may be required to squeeze the head out from the mold half because nose 28 must be flattened to squeeze out of the undercut portion 37 of the mold that defined the shape of the nose. Sleeve 11 is retained in a fixed position relative to ejector pin 13. This may be accomplished by a flanged limit stop 41 on the bottom of the core sleeve 11. Ejector pin 13 is pushed upward forcing the head to slide off of core sleeve 11 by stretching opening 45 in the bottom of the head around the widest part (i.e., major hollow dimension) 47 of core assembly 7.

As illustrated in Figure 6, doll head 27 is ejected from ejector pin 13 through injection of compressed gas through a tube in ejector pin 13. Doll head 27 is ejected readily from ejector pin 13 since it has a smaller major dimension than part 47 of core assembly 7. Doll head 27 has a top 31 formed in blow mold station mold front half 19 (illustrated in figure 2) and a bottom 33 that is formed in bottom mold half 5. At the junction where the top and bottom exterior mold halves meet, a part line 35 is created that is substantially a continuous circle around the top 31 of doll head 27 and above the usual location for the ears. Doll head 27 has a hollow interior 37 surrounding the core, and an opening 39 through which core sleeve 11 and ejector pin 13 pass and contact the bottom mold half 5. It is particularly advantageous for doll head 27 to have a part line 35 around the top of the head, as it is normal for doll head 27 to have hair-material rooted on both the top of the head and below the part line. The hair-material, which is made of any natural or synthetic material suitable to resemble hair, should have a sufficient strand density to cover part line 35 and to obscure part line 35 from observation by an ordinary observer holding doll head 27 at arms length. "Ordinary observer" means a person viewing a doll for purposes of casual observation or play, and not for detailed inspection. Doll head 27 may be painted with a suitable paint compatible with the thermoplastic elastomer used.

Process parameters employed in the instant invention will vary depending upon the elastomer used and the article to be manufactured. Of course, it should be understood that changes and modifications can be made to the preferred embodiments described above and that the foregoing detailed description is illustrative rather than limiting.